(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 893 332 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
20.03.2002 Bulletin 2002/12

(51) Int Cl.7: B62D 29/00

(21) Application number: 98305784.5

(22) Date of filing: 21.07.1998

(54) Method for reinforcing structural members

Verfahren zur Verstärkung von Konstruktionselementen

Procédé de renforcement d'éléments de construction

(84) Designated Contracting States:
AT BE DE ES FR GB IT NL SE

(30) Priority: 21.07.1997 US 53264 P
23.06.1998 US 103033

(43) Date of publication of application:
27.01.1999 Bulletin 1999/04

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(56) References cited:
WO-A-93/05103
DE-U- 9 320 333
US-A- 4 610 836

- PATENT ABSTRACTS OF JAPAN vol. 013, no. 267 (M-840), 20 June 1989 & JP 01 069309 A (MAZDA MOTOR CORP), 15 March 1989
- PATENT ABSTRACTS OF JAPAN vol. 013, no. 267 (M-840), 20 June 1989 & JP 01 069308 A (MAZDA MOTOR CORP), 15 March 1989
- PATENT ABSTRACTS OF JAPAN vol. 014, no. 501 (M-1043), 2 November 1990 & JP 02 206537 A (NITTO DENKO CORP), 16 August 1990

Printed by Jouve, 75001 PARIS (FR)

Description

[0001] The present invention relates generally to the reinforcement of hollow structural members and more specifically deals with reinforcement of structures having enclosed regions that present special access problems.

[0002] In recent years, a number of factors have necessitated fundamental changes in the approach to automotive structural design. These include the need to meet ever-increasing impact resistance and fuel economy standards and the need to produce a competitively priced vehicle in a global marketplace. At times, these requirements are seemingly at odds with one another. For example, impact resistance can in most cases be achieved simply by increasing steel thickness or through the use of high strength steels. These approaches, however, generally increase vehicle weight and/or cost. Although lightweight resins are available which can be used to fill entire hollow cavities of structural members to provide greater strength, these materials are expensive and thus their use in great quantities undesirably increases vehicle cost.

[0003] The present inventor has pioneered a novel approach to structural part reinforcement through localized reinforcement of critical regions using microsphere-filled thermally expandable resins, such as: a composite door beam which has a resin-based core that occupies not more than one-third of the bore of a metal tube; a hollow laminate beam characterized by high stiffness-to-mass ratio and having an outer portion which is separated from an inner tube by a thin layer of structural foam, a W-shaped carrier insert reinforcement which carries a foam body for use in reinforcing a hollow beam; a bulkhead that utilizes a thermally expandable foam to provide localized reinforcement of a rail for the attachment of an engine cradle or the like.

[0004] Although these techniques are well suited for a number of applications, there exists a need for localized reinforcement of regions having special access problems. More specifically, in a number of hollow structural parts the member has an enclosed region or space which is located some distance from the opening of the space and is difficult to reach due to a curvature or bend in the member. In some instances the member and the channel which it defines have an irregular geometry that makes access to a particular internal region difficult. Of course, in some instances it may be possible to simply fill the entire structure with a liquid resin which is then cured, but as stated above, this approach may be prohibitively expense in a number of applications.

[0005] JP01069309 describes a method for introducing a foaming agent into a porous reinforcing structural member located in an enclosed section. A hole is bored into the body and a foaming agent poured in. The subject-matter of this document forms the basis for the preamble of claim 28.

[0006] WO93/05103 discloses strengthening a hollow member by inserting a foam precursor means within the member and thereafter heating the structure. A heat sink formed from a length of light gauge steel tubing, carrying a liquid foam precursor mixture in an envelope is located in a fixed position within the hollow member. This document discloses a structural reinforcement member according to the preamble of claims 1 and 20.

[0007] Accordingly, there is a need for an alternative method of providing localized reinforcement of such parts. The present invention provides a solution to this problem.

[0008] According to a first aspect of the present invention there is provided a structural reinforcement member comprising a flexible member, which bends as pressure is applied such that it can be fed into a hollow structural part having a cavity of non-straight linear geometry and go through at least one bend, having a length greater than its diameter or width characterised in that at least a portion of an external surface of said length of said flexible member is covered with a layer or coat of an expandable resin which will bend with the flexible member as pressure is applied to the flexible member.

[0009] It is a further object of the present invention to provide a method of introducing a localized resin reinforcement in a structural part where the region to be reinforced is beyond a curvature in a channel.

[0010] It is still a further object of the present invention to provide a method of centralizing a resin reinforcement in a hollow structural part in a region which is difficult to access.

[0011] According to a second aspect of the present invention there is provided a method of reinforcing a hollow structural part having a cavity of non straight linear geometry and at least one bend with reinforcement at said bend characterised in that it comprises the steps of:

inserting a flexible member into the cavity of said hollow structural part,
bending and feeding the flexible member through the cavity until the expandable resin is located at the bend; and
expanding the expandable resin such that the expandable resin is bonded to said hollow structural part at the bend.

[0012] In one embodiment the present invention provides a method of reinforcing a part in a localized region. The method includes the steps of providing a flexible member having a length substantially greater than its width; covering at least a portion of the flexible member with a thermally expandable resin; and inserting the flexible member into the cavity of a hollow structural part. The insertion step includes the step of bending the flexible member to accommodate the geometry of the part cavity. The resin is then thermally expanded such that the resin is bonded to the structural

part. In this manner, localized reinforcement can be achieved for any number of parts whose internal geometry would make it difficult or impossible to reinforce using conventional techniques.

[0013] According to a third aspect of the present invention there is a reinforced hollow rigid structural part having an elongated cavity of non straight linear geometry and at least one bend said hollow structural part being reinforced at said bend by an expanded resin which is a structural foam expanded into intimate contact with and bonded to said hollow structural part at the bend said reinforced hollow structural part being characterised in that a flexible member runs longitudinally through the cavity of said hollow structural part and the expanded resin at the bend.

[0014] In one embodiment, the flexible member is a tube around which the resin is applied as a layer or coating. The resin-coated tube is then inserted in the structural part and bends as pressure is applied such that it can be fed into the part cavity, i.e. it conforms to the desired shape as it is inserted into the part.

[0015] In one embodiment, the resin includes a blowing agent and glass microspheres. After the flexible member is in place in the part, the part is heated, for example after installation in a motor vehicle, to a temperature sufficient to activate the blowing agent and thermally expand the resin. As the resin expands it bonds to the inner walls of the part forming a tube-in-tube type structure with high strength characteristics.

[0016] In one embodiment, the thermally expanded resin includes, in parts by weight, from about 40% to about 80% resin, from about 10% to about 50% microspheres, from about 0.5% to about 5% blowing agent, from about 1% to about 15% filler, from about 0.5% to about 2% accelerator and from about 1% to about 8% curing agent.

[0017] In still another embodiment, the flexible member includes one or more stand-offs which space it from the inner walls of the structural part.

[0018] These and other aspects, features and objects of the invention will be more fully described in the following detailed description of the preferred embodiments of the invention with reference to the drawings.

Figure 1 illustrates a resin support tube used in the method of the present invention.

Figure 2 illustrates a side elevational view partly in section showing the position of the unexpanded resin on the resin support tube.

Figure 3 illustrates another resin support tube with a covering of unexpanded resin.

Figure 4 depicts a curved structural member in cross-section to reveal the resin support tube in position prior to expansion of the resin.

Figure 5 depicts the curved structural member of Figure 4 in cross-section, revealing the expanded resin forming an internal reinforcement.

Figure 6 is a front view of a resin support tube having radial stand-offs for use in the present invention.

Figure 7 is an end view of the support tube of Figure 6 in the direction of arrow 7-7.

Figure 8 depicts a curved structural member in cross-section, revealing the unexpanded resin and the placement of the stand-offs.

[0019] Referring to Figures 1 and 2 of the drawings, flexible member or tube 20 is shown which serves as a support for unexpanded resin sheath 22. Flexible member 20 is most preferably a hollow tube similar to that used as a conduit for electrical wiring 23. Various flexible conduits will be known to those skilled in the art. One particular preferred flexible conduit is a metallic spiral tube which can be flexed without metal deformation due to its spiral construction. Of course, it may not be necessary for tube 20 to be round in cross section and other configurations such as square or oval may be suitable. Where flexible member 20 is a hollow metal tube it will typically be formed of aluminum and will preferably have a wall thickness of from about .5 to about 1.2 mm. The diameter of tube 20 will vary depending upon the application, but will typically be from about 8 to about 40 mm and will typically have a length of from about 50 to about 800 and preferably 200 mm in most automotive applications. In some applications, tube 20 will be deformed beyond its elastic limit during placement in the structure to be reinforced. In addition, in some applications a more elastic tube or rod can be used which is essentially spring biased in position in the structural cavity. Although hollow tube 20 is most preferred, particularly since it provides a lightweight structure, solid rods may also be used. It may be desirable to use plastic rods or tubes, rather than metal, as tube 20 in some applications.

[0020] The length of tube 20 is a function of the distance to the site to be reinforced from the cavity opening. The length of tube 20 is greater than its diameter or width and in many applications tube 20 will be preferably at least 5 times or may be 20 times and often more than 100 times longer than its diameter in cross section. In many applications, tube 20 will have a length of from about 50 to about 200 mm. Also, in some applications, it may be desirable to cover substantially all of tube 20a, shown as a spiral conduit in Figure 3, with resin sheath 22a.

[0021] Resin sheath 22 in most applications will be a layer extending around the entire outer surface of tube 20 and will usually be of relatively uniform thickness, for example from about 2 to about 6 mm, in the unexpanded state. Resin sheath 22 can be prepared by die cutting a sheet of resin to the requisite geometry and the wrapping the pre-cut sheet around tube 20. Alternatively, the coating may be molded on the carrier, although it may be possible to use other forms of coating, such as by spraying or the like.

[0022] The polymer used to form resin sheath 22 is a resin based material which is preferably thermally expandable. A number of resin-based compositions can be utilized to form resin sheath 22 in the present invention. The preferred compositions impart excellent strength and stiffness characteristics while adding only marginally to the weight. With specific reference now to the composition of sheath 22, the density of the material should preferably be from about (0.32 g cm^{-3} (20 pounds per cubic feet) to about 0.80 g cm^{-3} (50 pounds per cubic feet) to minimize weight. The melting point, heat distortion temperature and the temperature at which chemical breakdown occurs must also be sufficiently high such that sheath 22 maintains its structure at high temperatures typically encountered in pain ovens and the like. Therefore, sheath 22 should be able to withstand temperatures in excess of 160° C (320 degrees F.) and preferably 176°C (350 degrees F.) For short times. Also, sheath 22 should be able to withstand heats of about 32°C (90 degrees F.) To 93 °C (200 degrees F.) For extended periods without exhibiting substantial heat-induced distortion or degradation.

[0023] In more detail, in one particularly preferred embodiment the thermally expanded structural foam of sheath 22 includes a synthetic resin, a cell-forming agent, and a filler. A synthetic resin comprises from about 40 percent to about 80 percent by weight, preferably from about 45 percent to about 75 percent by weight, and most preferably from about 50 percent to about 70 percent by weight of sheath 22. Most preferably, a portion of the resin includes a flexible epoxy. As used herein, the term "cell-forming agent" refers generally to agents which produce bubbles, pores, or cavities in sheath 22. That is, sheath 22 has a cellular structure, having numerous cells disposed throughout its mass. This cellular structure provides a low-density, high-strength material, which provide a strong, yet lightweight structure. Cell-forming agents which are compatible with the present invention include reinforcing "hollow" microspheres or microbubbles which may be formed of either glass or plastic. Glass microspheres are particularly preferred. Also, the cell-forming agent may comprise a blowing agent which may be either a chemical blowing agent or a physical blowing agent. Where the cell-forming agent comprises microspheres or macrospheres, it constitutes from about 10 percent to about 50 percent by weight, preferably from about 15 percent to about 45 percent by weight, and most preferably from 20 percent to about 40 percent by weight of the material which forms sheath 22. Where the cell-forming agent comprises a blowing agent, it constitutes from about 0.5 percent to about 5.0 percent by weight, preferably from about 1 percent to about 4.0 percent by weight, and most preferably from about 1 percent to about 2 percent by weight of sheath 22. Suitable fillers include glass or plastic microspheres, fumed silica, calcium carbonate, milled glass fiber, and chopped glass strand. A thixotropic filler is particularly preferred. Other materials may be suitable. A filler comprises a from about 1 percent to about 15 percent by weight, preferably from about 2 percent to about 10 percent by weight and most preferably from about 3 percent to about 8 percent y weight of sheath 22.

[0024] Preferred synthetic resins for use in the present invention include thermosets such as epoxy resins, vinyl ester resins, thermoset polyester resins, and urethane resins. It is not intended that the scope of the present invention be limited by molecular weight of the resin and suitable weights will be understood by those skilled in the art based on the present disclosure. Where the resin component of the liquid filler material is a thermoset resin, various accelerators, such as imidizoles and curing agents, preferably dicyandiamide may also be included to enhance the cure rate. A functional amount of accelerator is typically from about 0.5 percent to about 2.0 percent of the resin weight with corresponding reduction in one of the three components, resin, cell-forming agent or filler. Similarly, the amount of curing agent used is typically from about 1 percent to about 8 percent of the resin weight with a corresponding reduction in one of the three components, resin, cell-forming agent or filler. Effective amounts of processing aids, stabilizers, colorants, UV absorbers and the like may also be included in layer. Thermoplastics may also be suitable.

[0025] In the following table, a preferred formulation for sheath 22 is set forth. It has been found that this formulation provides a material which fully expands and cures at about 160°C 320 degrees F.) and provides excellent structural properties. All percentages in the present disclosure are percent by weight unless otherwise specifically designated.

INGREDIENT	PERCENTAGE BY WEIGHT
EPON 828 (epoxy resin)	37.0
DER 331 (flexible epoxy resin	18.0
DI-CY (dicyandiamide curing agent)	4.0
IMIDIZOLE (accelerator)	0.8
FUMED SILICA (thixotropic filler)	1.1
CELOGEN (RTM) AZ199 (azodicarbonamide blowing agent)	1.2
B38 MICROS (glass microspheres)	37.0
WINNOFIL (RTM) CALCIUM CARBONATE ($CaCO_3$ filler)	0.9

[0026] Referring now to Figure 4 of the drawings, structural part 24 is seen in cross section and defines cavity 26.

For the purpose of illustration only, structural part 24 is shown here as a portion of an automotive roll bar. Other preferred applications are for use in reinforcing top A-pillar joints and seat frames. Structural part 24 has an arcuate or curved portion 28 which defines an arcuate portion 30 of cavity 26. Cavities similar to cavity 26, i.e. those which are difficult to access, are the focus of the present invention. Flexible tube 20 is shown in position in cavity 26 prior to thermal expansion of the resin. Tube 20 is bent to conform to the shape of cavity 26. This shaping operation is preferably performed in place. In other words, flexible tube 20, having resin sheath 22 positioned at a preselected location relative to the ends of tube 20, in inserted into cavity 26. As force is applied to tube 20 it moves farther through the passage. As it encounters resistance from the inner walls 32, flexible tube 20 bends, thereby "snaking" its way through cavity 26, including beyond arcuate portion 30. Alternatively, it may be possible in some applications to bend tube 20 to a conforming geometry prior to inserting it into cavity 26. Flexible tube 20 is inserted a distance sufficient to bring resin sheath 22 into position at arcuate portion 28. Once in position, outer end 34 of tube 20 is clamped into position relative to tube 20 with a clamp (not shown) or otherwise fixed in position, if required.

[0027] The cavity 26 is of non-straight linear geometry which could be more complicated than having simply one bend with its arcuate portion such as illustrated in Figure 4. Where there are multiple bends or irregularities a resin sheath 22 could be provided for some or all of these irregularities, this could be done by providing individual spaced resin sections or by providing one or more continuous resin sections which are located at two or more bends.

[0028] Referring now to Figure 5 of the drawings, resin 22 is shown in the expanded state. That is, once tube 20 and resin 22 are in position in structural part 24, the resin is expanded by heating the entire assembly to a temperature which activates the blowing agent to expand and cure resin sheath 22. In automotive applications that is typically achieved as the vehicle moves through the paint oven. Resin 22 expands to several times its original volume, preferably at least twice its original volume. The expanded resin contacts and bonds firmly to surrounding walls 32 of structural part 24. It also cures to form a rigid reinforcement in part 24. In this manner, a minimum amount of resin is used at the precise location where reinforcement is required.

[0029] Referring now to Figures 6 and 7 of the drawings, tube 20 is provided with radical stand-off assembly 36 which has legs 38, typically two to four in number. As seen in Figure 8, stand-off assembly 36 serves the function of generally centering tube 20 in structural part 24. It may be preferable to make legs 38 somewhat resilient, i.e. it may be desirable to allow legs 38 to flex inwardly as tube 20 is inserted into cavity 26.

[0030] While the invention has been described primarily in connection with automotive or vehicle parts, it is to be understood that the invention may be practiced as part of other products, such as aircrafts, ships, bicycles or virtually anything that requires energy for movement. Similarly, the invention may be used with stationary or static structures, such as buildings, to provide a rigid support when subjected to vibration such as from an earthquake ro simply to provide a lightweight support for structures subjected to loads. Additionally, while the invention has been described primarily with respect to heat expandable foams and with respect to metal parts such as the structural part and the flexible member, other materials can be used. For example, the foam could be any suitable known expandable foam which is chemically activated into expansion and forms a rigid structural foam. The flexible member could be made of materials other than metal such as various plastics or polymeric materials or various wood type fibrous materials having sufficient rigidity to function as a back drop or support for the foam. Where a heat expandable foam is used the flexible member should be able to withstand the heat encountered during the heat curing. Where other types of foam materials are used, however, it is not necessary that the flexible member be able to withstand high temperatures. Instead, the basic requirement for the flexible member is that it have sufficient rigidity to function in its intended manner. It is also possible, for example, to use as the flexible member materials which in themselves be come rigid upon curing or further treatment. The invention may also be practiced where the structural part is made of materials other than metal. It is preferred, however, that materials be selected for the structural part and flexible member, as well as the foam, so that the thin unexpanded foam upon expansion forms a strong bond with the structural part and flexible member, so that a structural composition will result.

[0031] While particular embodiments of this invention are shown and described herein, it will be understood, of course, that the invention is not be limited thereto since many modifications may be made, particularly by those skilled in this art, in light of this disclosure. It is contemplated, therefore, by the appended claims, to cover any such modifications as fall within the scope of this invention.

Claims

1. A structural reinforcement member comprising a flexible member (20), which bends as pressure is applied such that it can be fed into a hollow structural part (24) having a cavity (26) of non-straight linear geometry and go through at least one bend (28), having a length greater than its diameter or width **characterised in that** at least a portion of an external surface of said length of said flexible member (20) is covered with a layer or coat of an expandable resin (22) which will bend with the flexible member as pressure is applied to the flexible member.

2. A structural reinforcement member as claimed in claim 1, wherein the length of the flexible member (20) is at least five times its diameter or width.

3. A structural reinforcement member as claimed in claim 1 or 2, further comprising a stand-off assembly (36) for generally centering the flexible member (20) in the structural part (24).

4. A structural reinforcement member as claimed in claim 1, 2 or 3, wherein the flexible member (20) is hollow.

5. A structural reinforcement member as claimed in claim 1, 2, 3 or 4, wherein said flexible member (20) has a spiral construction.

6. A structural reinforcement member as claimed in claim 1,2 or 3, wherein the flexible member (20) is solid.

7. A structural reinforcement member as claimed in any of the preceding claims, wherein the expandable resin (22) is thermally expandable and contains hollow microspheres.

8. A structural reinforcement member as claimed in any of the preceding claims, wherein the diameter of the flexible member (20) is from 8 to 40 mm and its length is from 50 to 200mm.

9. A structural reinforcement member as claimed in any of the preceding claims wherein the layer (22) encircles and encases at least a portion of the flexible member.

10. A structural reinforcement member as claimed in any of the preceding claims, wherein the layer (22) has a uniform thickness of from 2 to 8 mm.

11. A structural reinforcement member as claimed in claim 4 having a wall thickness of from 0.5 to 1.2 mm.

12. A structural reinforcement member as claimed in any of the preceding claims, wherein the flexible member (20) is formed of metal.

13. A structural reinforcement member as claimed in claim 12, wherein the metal is aluminium.

14. A structural reinforcement member as claimed in any of the preceding claims which is substantially covered by the expandable resin (22).

15. A structural reinforcement member as claimed in any of the preceding claims, wherein the expandable resin (22) is thermally expandable and includes, in parts by weight, from 40% to 80% resin, from 10% to 50% microspheres, from 0.5% to 5% blowing agent, from 1% to 15% filler, from 0.5% to 2% accelerator and from 1% to 8% curing agent.

16. A structural reinforcement member as claimed in any of the preceding claims, wherein the resin (22) is thermally expandable and includes, in parts by weight, 55% epoxy resin, 4% dicyandiamide curing agent, 0.8% imidizole accelerator, 1.1% fumed silica, 1.2% azodicarbonamide blowing agent, 37% glass microspheres, and 0.9% calcium carbonate filler.

17. A structural reinforcement as claimed in any of claims 1 to 5 or 7 to 16, wherein the flexible member (20) is a hollow tube with electrical wiring extending longitudinally therein.

18. A structural reinforcement member as claimed in any of the preceding claims, wherein the expandable resin (22) is a die cut sheet which is wrapped around the flexible member or is a coat molded onto the flexible member (20).

19. A structural reinforcement member as claimed in any of claims 1 to 18 in which the expandable resin (22) is able to withstand a temperature of about 32°C to 93°C for extended periods without exhibiting substantially heat induced distortion or degradation.

20. A method of reinforcing a hollow structural part (24) having a cavity (26) of non straight linear geometry and at least one bend (28) with reinforcement (22) at said bend (28) **characterised in that** it comprises the steps of:

inserting a structural reinforcement member (20) as claimed in any of claims 1 to 19 into the cavity (26) of said

hollow structural part (24),
bending and feeding the structural reinforcement member (20) through the cavity (26) until the expandable resin (12) is located at the bend (28); and
expanding the expandable resin such that the expandable resin is bonded to said hollow structural part (24) at the bend (28).

21. The method of reinforcing a part as claimed in claim 20, wherein the part is selected from the group consisting of an A-pillar joint, a seat frame and a roll-bar for a motor vehicle.

22. The method of reinforcing a part as claimed in claim 20 or 21 wherein the structural reinforcement member has an attached stand-off assembly (36) for spacing the structural reinforcement member from the part inner walls prior to the expansion step.

23. The method of reinforcing a hollow structural part as claimed in any of claims 20 to 22, wherein the structural reinforcement member is inelastically deformed prior to the insertion step, the deformation being such that the structural reinforcement member conforms to the geometry of the cavity (26).

24. The method of reinforcing a hollow structural part as claimed in any of claims 20 to 22, wherein the structural reinforcement member is shaped during the insertion step by contact with the hollow structural part (24).

25. The method of reinforcing a hollow structural part as claimed in any of claims 20 to 24, wherein the structural reinforcement member is secured in the hollow structural part (24) prior to the expansion step.

26. The method of reinforcing a hollow structural part as claimed in any of claims 20 to 25, wherein there are a plurality of bends, and the resin (22) is located at more than one of the bends.

27. The method of reinforcing a hollow structural part as claimed in any of claims 20 to 26, wherein the part is a vehicle part, the resin (22) is thermally expandable, and the resin is expanded in a vehicle paint oven during a painting step.

28. A reinforced hollow rigid structural part (24) having an elongated cavity (26) of non straight linear geometry and at least one bend (28) said hollow structural part being reinforced at said bend (28) by an expanded resin (22) which is a structural foam expanded into intimate contact with and bonded to said hollow structural part (24) at the bend (28) said reinforced hollow structural part being **characterised in that** a flexible member (20) runs longitudinally through the cavity (26) of said hollow structural part (24) and the expanded resin (22) at the bend (28).

29. A reinforced hollow structural part as claimed in claim 28, wherein said hollow structural part is a vehicle part selected from the group consisting of a roll-bar, an A-pillar joint and a seat frame.

30. A reinforced hollow structural part as claimed in claim 28 or 29, wherein said flexible member (20) is hollow, and electrical wiring (23) extends longitudinally through said flexible member (20).

31. A reinforced hollow structural part as claimed in claim 28, 29 or 30 including at least one stand-off assembly (36, 38) mounted around said flexible member (20) at a location outwardly of said expanded resin (22), said stand-off assembly having a plurality of outwardly extending legs (38) in said cavity (26) in resilient contact with an inner surface of said hollow structural part (24).

Patentansprüche

1. Strukturverstärkungselement, das ein flexibles Element (20) aufweist, welches sich bei Ausüben von Druck derart verbiegt, dass es in einen hohlen Strukturteil (24) mit einem Hohlraum (26) nichtgerader linearer Geometrie eingeführt und durch wenigstens eine Krümmung (28) hindurchgehen kann, und welches eine größere Länge als seinen Durchmesser oder seine Breite aufweist, **dadurch gekennzeichnet, dass** wenigstens ein Teil einer Außenfläche der genannten Länge des genannten flexiblen Elementes (20) mit einer Schicht oder einem Überzug aus einem ausdehnbaren Harz (22) bedeckt ist, das sich mit dem flexiblen Element bei Ausüben von Druck auf das flexible Element verbiegen wird.

2. Strukturverstärkungselement nach Anspruch 1, bei dem die Länge des flexiblen Elements (20) wenigstens das

fünffache seines Durchmessers oder seiner Breite beträgt.

3. Strukturverstärkungselement nach Anspruch 1 oder 2, das weiter eine Abstandsbaugruppe (36) zum allgemeinen Zentrieren des flexiblen Elements (20) in dem Strukturteil (24) aufweist.

4. Strukturverstärkungselement nach Anspruch 1, 2 oder 3, bei dem das flexible Element (20) hohl ist.

5. Strukturverstärkungselement nach Anspruch 1, 2, 3 oder 4, bei dem das genannte flexible Element (20) einen spiralförmigen Aufbau hat.

6. Strukturverstärkungselement nach Anspruch 1, 2 oder 3, bei dem das flexible Element (20) massiv ist.

7. Strukturverstärkungselement nach einem der vorhergehenden Ansprüche, bei dem der ausdehnbare Harz (22) wärmeausdehnbar ist und hohle Mikrokügelchen enthält.

8. Strukturverstärkungselement nach einem der vorhergehenden Ansprüche, bei dem der Durchmesser des flexiblen Elements (20) von 8 bis 40 mm und seine Länge von 50 bis 200 mm beträgt.

9. Strukturverstärkungselement nach einem der vorhergehenden Ansprüche, bei dem die Schicht (22) wenigstens einen Teil des flexiblen Elements umschließt und einkapselt.

10. Strukturverstärkungselement nach einem der vorhergehenden Ansprüche, bei dem die Schicht (22) eine einheitliche Dicke von 2 bis 8 mm aufweist.

11. Strukturverstärkungselement nach Anspruch 4, das eine Wanddicke von 0,5 bis 1,2 mm aufweist.

12. Strukturverstärkungselement nach einem der vorhergehenden Ansprüche, bei dem das flexible Element (20) aus Metall gebildet ist.

13. Strukturverstärkungselement nach Anspruch 12, bei dem das Metall Aluminium darstellt.

14. Strukturverstärkungselement nach einem der vorhergehenden Ansprüche, das im wesentlichen durch das ausdehnbare Harz (22) bedeckt ist.

15. Strukturverstärkungselement nach einem der vorhergehenden Ansprüche, bei dem das ausdehnbare Harz (22) wärmeausdehnbar ist und in Gewichtsteilen von 40% bis 80% Harz, von 10% bis 50% Mikrokügelchen, von 0,5% bis 5% Treibmittel, von 1% bis 15% Füllmaterial, von 0,5% bis 2% Beschleuniger und von 1% bis 8% Härtungsmittel umfasst.

16. Strukturverstärkungselement nach einem der vorhergehenden Ansprüche, bei dem das Harz (22) wärmeausdehnbar ist und in Gewichtsteilen 55% Epoxidharz, 4% Dicyandiamid-Härtungsmittel, 0,8% Imidizol-Beschleuniger, 1,1% Kieselpuder, 1,2% Azodicarbonamid-Treibmittel, 37% Glasmikrokügelchen und 0,9% Kalziumcarbonat-Füllmaterial umfasst.

17. Strukturverstärkungselement nach einem der Ansprüche 1 bis 5 oder 7 bis 16, bei dem das flexible Element (20) ein hohles Rohr mit sich darin der Länge nach erstreckender Verdrahtung darstellt.

18. Strukturverstärkungselement nach einem der vorhergehenden Ansprüche, bei dem das ausdehnbare Harz (22) eine ausgestanzte Folie darstellt, die um das flexible Element gewickelt wird, oder ein auf das flexible Element (20) gegossener Überzug ist.

19. Strukturverstärkungselement nach einem der Ansprüche 1 bis 18, in dem das ausdehnbare Harz (22) einer Temperatur von etwa 32°C bis 93°C für ausgedehnte Zeitspannen standhalten kann, ohne im wesentlichen durch Wärme verursachte Verzerrung oder Verschlechterung zu zeigen.

20. Verfahren zum Verstärken eines hohlen Strukturteils (24), der einen Hohlraum (26) nichtgerader linearer Geometrie und wenigstens eine Krümmung (28) mit Verstärkung (22) an der genannten Krümmung (28) aufweist, **dadurch gekennzeichnet, dass** es die folgenden Schritte aufweist:

Einführen eines Strukturverstärkungselements (20) nach einem der Ansprüche 1 bis 19 in den Hohlraum (26) des genannten hohlen Strukturteils (24),

Biegen und Führen des Strukturverstärkungselements (20) durch den Hohlraum (26), bis das ausdehnbare Harz (12) an der Krümmung (28) angeordnet ist; und

Ausdehnen des ausdehnbaren Harzes derart, dass das ausdehnbare Harz an den genannten hohlen Strukturteil (24) an der Krümmung (28) gebunden wird.

21. Verfahren zum Verstärken eines Teils nach Anspruch 20, bei dem der Teil von der Gruppe ausgewählt ist, die aus einer A-Pfeilerverbindung, einem Sitzrahmen und einer Rollschiene für ein Kraftfahrzeug besteht.

22. Verfahren zum Verstärken eines Teils nach Anspruch 20 oder 21, bei dem das Strukturverstärkungselement eine befestigte Abstandsbaugruppe (36) zum Beabstanden des Strukturverstärkungselements von der Teilinnenwand vor dem Ausdehnungsschritt umfasst.

23. Verfahren zum Verstärken eines hohlen Strukturteils nach einem der Ansprüche 20 bis 22, bei dem das Strukturverstärkungselement unelastisch vor dem Einführungsschritt verformt wird, wobei die Verformung derart ist, dass das Strukturverstärkungselement der Geometrie des Hohlraums (26) entspricht.

24. Verfahren zum Verstärken eines hohlen Strukturteils nach einem der Ansprüche 20 bis 22, bei dem das Strukturverstärkungselement während des Einführungsschritts durch Kontakt mit dem hohlen Strukturteil (24) geformt wird.

25. Verfahren zum Verstärken eines hohlen Strukturteils nach einem der Ansprüche 20 bis 24, bei dem das Strukturverstärkungselement in dem hohlen Strukturteil (24) vor dem Ausdehnungsschritt befestigt wird.

26. Verfahren zum Verstärken eines hohlen Strukturteils nach einem der Ansprüche 20 bis 25, bei dem eine Anzahl von Krümmungen vorliegt, und das Harz (22) an mehr als einer der Krümmungen vorgesehen wird.

27. Verfahren zum Verstärken eines hohlen Strukturteils nach einem der Ansprüche 20 bis 26, bei dem der Teil einen Fahrzeugteil darstellt, das Harz (22) wärmeausdehnbar ist und das Harz in einem Fahrzeugfarbofen während eines Lackierschritts ausgedehnt wird.

28. Verstärkter hohler starrer Strukturteil (24) mit einem länglichen Hohlraum (26) nichtgerader linearer Geometrie und wenigstens einer Krümmung (28), wobei der genannte hohle Strukturteil an der genannten Krümmung (28) durch ein ausgedehntes Harz (22) verstärkt wird, das ein in engen Kontakt mit dem genannten hohlen Strukturteil (24) an der Krümmung (28) ausgedehnter und an den selben gebundener Strukturschaum ist, wobei der genannte verstärkte hohle Strukturteil **dadurch gekennzeichnet ist, dass** ein flexibles Element (20) der Länge nach durch den Hohlraum (26) des genannten hohlen Strukturteils (24) und des ausgedehnten Harzes (22) an der Krümmung (28) verläuft.

29. Verstärkter hohler Strukturteil nach Anspruch 28, bei dem der genannte hohle Strukturteil ein Fahrzeugteil ist, der von der Gruppe ausgewählt ist, die aus einer Rollschiene, einer A-Pfeilerverbindung und einem Sitzrahmen ausgewählt ist.

30. Verstärkter hohler Strukturteil nach Anspruch 28 oder 29, bei dem das genannte flexible Element (20) hohl ist, und elektrische Verdrahtung (23) sich der Länge nach durch das genannte flexible Element (20) erstreckt.

31. Verstärkter hohler Strukturteil nach Anspruch 28, 29 oder 30, der wenigstens eine Abstandsbaugruppe (36, 38) umfasst, die um das genannte flexible Element (20) herum an einer Stelle außerhalb von dem genannten ausgedehnten Harz (22) angebracht ist, wobei die genannte Abstandsgruppe eine Anzahl von sich nach außen erstrekkenden Beinen (38) in dem genannten Hohlraum (26) in federndem Kontakt mit einer Innenfläche des genannten hohlen Strukturteils (24) aufweist.

Revendications

1. Elément de construction de renforcement comprenant un élément flexible (20) qui fléchit au fur et à mesure que

la pression est appliquée, de telle sorte qu'il est possible de l'introduire dans une pièce de construction creuse (24) possédant une cavité (26) de géométrie linéaire non rectiligne et de le faire passer par un coude (28) au moins, dont la longueur est supérieure à son diamètre ou à sa largeur, **caractérisé en ce qu'**une section au moins d'une surface externe de ladite longueur dudit élément flexible (20) est recouverte d'une couche ou d'un revêtement de résine expansible (22) qui fléchira avec l'élément flexible au fur et à mesure que la pression est appliquée sur l'élément flexible.

2. Elément de construction de renforcement, selon la revendication 1, dans lequel la longueur de l'élément flexible (20) est au moins égale à cinq fois son diamètre ou sa largeur.

3. Elément de construction de renforcement, selon la revendication 1 ou 2, comprenant en outre un ensemble d'écartement (36) destiné à centrer généralement l'élément flexible (20) dans la pièce de construction (24).

4. Elément de construction de renforcement, selon la revendication 1, 2 ou 3, dans lequel l'élément flexible (20) est creux.

5. Elément de construction de renforcement, selon la revendication 1, 2, 3 ou 4, dans lequel ledit élément flexible (20) a une construction spiralée.

6. Elément de construction de renforcement, selon la revendication 1, 2 ou 3, dans lequel l'élément flexible (20) est plein.

7. Elément de construction de renforcement, selon l'une quelconque des revendications précédentes, dans lequel la résine expansible (22) est thermiquement expansible et contient des microsphères creuses.

8. Elément de construction de renforcement, selon l'une quelconque des revendications précédentes, dans lequel le diamètre de l'élément flexible (20) est de 8 à 40 mm et sa longueur de 50 à 200 mm.

9. Elément de construction de renforcement, selon l'une quelconque des revendications précédentes, dans lequel la couche (22) encercle et recouvre au moins une section de l'élément flexible.

10. Elément de construction de renforcement, selon l'une quelconque des revendications précédentes, dans lequel la couche (22) a une épaisseur uniforme de 2 à 8 mm.

11. Elément de construction de renforcement, selon la revendication 4, ayant une épaisseur de paroi de 0,5 à 1,2 mm.

12. Elément de construction de renforcement, selon l'une quelconque des revendications précédentes, dans lequel l'élément flexible (20) est réalisé en métal.

13. Elément de construction de renforcement, selon la revendication 12, dans lequel le métal est de l'aluminium.

14. Elément de construction de renforcement, selon l'une quelconque des revendications précédentes, qui est essentiellement recouvert du résine expansible (22).

15. Elément de construction de renforcement, selon l'une quelconque des revendications précédentes, dans lequel la résine expansible (22) est thermiquement expansible et contient, en parties en poids, de 40% à 80% de résine, de 10% à 50% de microsphères, de 0,5% à 5% d'agent gonflant, de 1% à 15% de matière de remplissage, de 0,5% à 2% d'accélérateur et de 1% à 8% d'agent durcisseur.

16. Elément de construction de renforcement, selon l'une quelconque des revendications précédentes, dans lequel la résine (22) est thermiquement expansible et contient, en parties en poids, 55% de résine époxyde, 4% d'agent durcisseur dicyandiamide, 0,8% d'accélérateur imidizole, 1,1% de silice pyrogénée, 1,2% d'agent gonflant azodicarbonamide, 37% de microsphères de verre et 0,9% de matière de remplissage sous forme de carbonate de calcium.

17. Elément de construction de renforcement, selon l'une quelconque des revendications 1 à 5 ou 7 à 16, dans lequel l'élément flexible (20) est un tube creux avec un câblage électrique qui se prolonge dans celui-ci selon un sens longitudinal.

18. Elément de construction de renforcement, selon l'une quelconque des revendications précédentes, dans lequel la résine expansible (22) est une feuille découpée à l'emporte-pièce qui est enveloppée autour de l'élément flexible ou bien est un revêtement qui a été moulé sur l'élément flexible (20).

19. Elément de construction de renforcement, selon l'une quelconque des revendications 1 à 18, dans lequel la résine expansible (22) est capable de résister à une température d'environ 32°C à 93°C pendant des périodes prolongées sans présenter de dégradation ou de distorsion qui soit provoquée essentiellement par la chaleur.

20. Procédé de renforcement d'une pièce de construction creuse (24) possédant une cavité (26) de géométrie linéaire non rectiligne et au moins un coude (28) avec un renforcement (22) au niveau dudit coude (28), **caractérisé en ce qu'**il comporte les étapes suivantes :

introduction d'un élément de construction de renforcement (20), selon l'une quelconque des revendications 1 à 19, dans la cavité (26) de ladite pièce de construction creuse (24),
fléchissement et acheminement de l'élément de construction de renforcement (20) par la cavité (26) jusqu'à ce que la résine expansible (12) soit positionnée au niveau du coude (28); et
expansion de la résine expansible de telle sorte que la résine expansible soit liaisonnée sur ladite pièce de construction creuse (24) au niveau du coude (28).

21. Procédé de renforcement d'une pièce, selon la revendication 20, dans lequel la pièce est sélectionnée parmi un groupe constitué d'un raccord de montant A, d'une armature de siège et d'un arceau de sécurité pour un véhicule à moteur.

22. Procédé de renforcement d'une pièce, selon la revendication 20 ou 21, dans lequel l'élément de construction de renforcement est muni d'un ensemble d'écartement (36) destiné à maintenir une distance entre l'élément de construction de renforcement et les parois internes de la pièce avant l'étape d'expansion.

23. Procédé de renforcement d'une pièce de construction creuse, selon l'une quelconque des revendications 20 à 22, dans lequel l'élément de construction de renforcement est soumis à une déformation inélastique avant l'étape d'introduction, la déformation étant telle que l'élément de construction de renforcement adopte la géométrie de la cavité (26).

24. Procédé de renforcement d'une pièce de construction creuse, selon l'une quelconque des revendications 20 à 22, dans lequel l'élément de construction de renforcement est façonné au cours de l'étape d'introduction suite au contact avec la pièce de construction creuse (24).

25. Procédé de renforcement d'une pièce de construction creuse, selon l'une quelconque des revendications 20 à 24, dans lequel l'élément de construction de renforcement est immobilisé dans la pièce de construction creuse (24) avant l'étape d'expansion.

26. Procédé de renforcement d'une pièce de construction creuse, selon l'une quelconque des revendications 20 à 25, dans lequel il existe une pluralité de coudes, et la résine (22) est placée sur plus d'un des coudes.

27. Procédé de renforcement d'une pièce de construction creuse, selon l'une quelconque des revendications 20 à 26, dans lequel la pièce est une pièce de véhicule, la résine (22) est thermiquement expansible, et la résine est expansée dans un four de peinture de véhicules pendant une étape d'application de la peinture.

28. Pièce de construction (24) creuse, rigide et renforcée possédant une cavité allongée (26) de géométrie linéaire non rectiligne et au moins un coude (28), ladite pièce de construction creuse étant renforcée au niveau dudit coude (28) par une résine expansée (22) qui est une mousse structurée, expansée jusqu'à ce qu'elle soit en contact étroit et en liaisonnement avec ladite pièce de construction creuse (24) au niveau du coude (28), ladite pièce de construction creuse renforcée étant **caractérisée en ce qu'**un élément flexible (20) passe dans le sens longitudinal à travers la cavité (26) de ladite pièce de construction creuse (24) et la résine expansée (22) au niveau du coude (28).

29. Pièce de construction creuse renforcée, selon la revendication 28, dans laquelle ladite pièce de construction creuse est une pièce de véhicule qui est sélectionnée parmi un groupe constitué d'un arceau de sécurité, d'un raccord de montant A et d'une armature de siège.

30. Pièce de construction creuse renforcée, selon la revendication 28 ou 29, dans laquelle ledit élément flexible (20) est creux, et un câblage électrique (23) se prolonge à travers ledit élément flexible (20) dans un sens longitudinal..

31. Pièce de construction creuse renforcée, selon la revendication 28, 29 ou 30, comprenant au moins un ensemble d'écartement (36, 38) qui est monté autour dudit élément flexible (20) en un emplacement à l'extérieur de ladite résine expansée (22), ledit ensemble d'écartement possédant une pluralité de pattes (38) s'étendant vers l'extérieur dans ladite cavité (26) en contact élastique avec une surface interne de ladite pièce de construction creuse (24).

Fig.1.

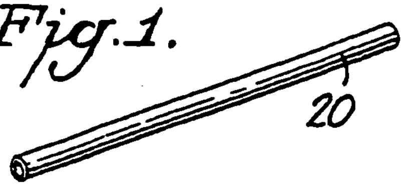


Fig.3.

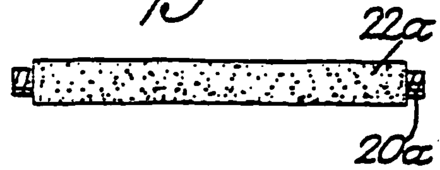
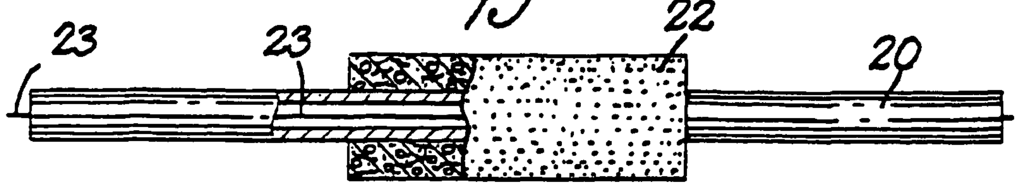


Fig.2



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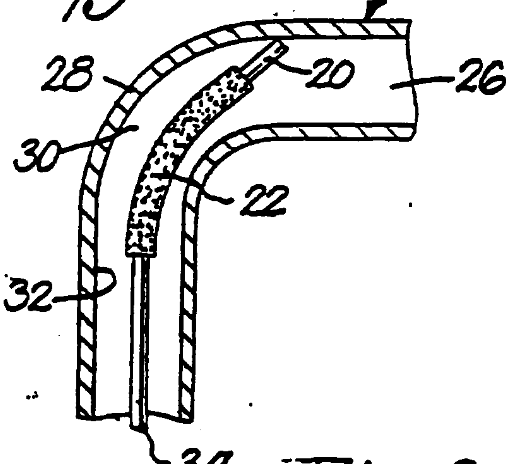


Fig.5.

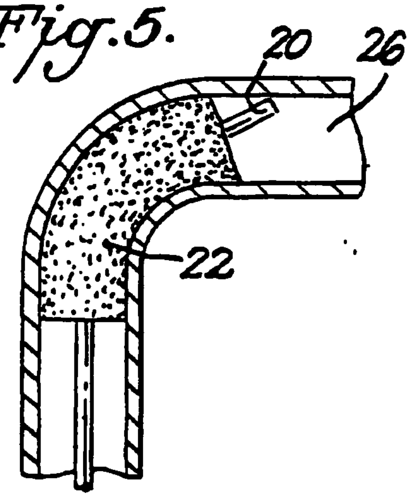
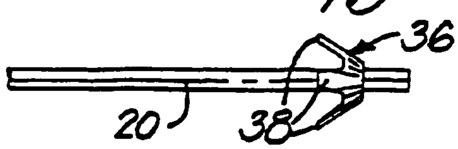


Fig.6.



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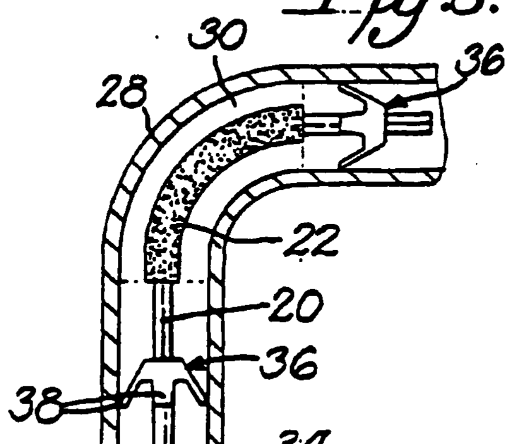

Fig.7.